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A PRELIMINARY STUDY OF THE DIAMETER GROWTH OF PONDEROSA PINE AND OF SOME OF ITS RELATIONS WITH RISK AND INCIPIENT INFESTATIONS OF THE FLATHEAD BORER (Melanophila californica VD.)

by
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Berkeley, California
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A PRELIMINARY STUDY OF THE DIAMETER GROWTH OF PONDEROSA PINE AND OF SOME OF ITS RELATIONS WITH RISK AND INCIPIENT INFESTATIONS OF THE FLATHEAD BORER (Melanophila californica VD.)

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INTRODUCTION

The question has been raised as to whether trees bearing incipient brood infestations of the flathead borer (Melanophila californica VD) are growing and thus living trees or whether growth has ceased and the egg laying by adult beetles and larval attacks follow on trees which actually are dead.

Considerable information, which may shed some light on that question, has been collected at Timber Mountain on the Modoc National Forest. It is analyzed in this report.

Much of the material consists of cores taken from trees to which risk ratings had previously been applied. On some trees basal examinations of small phloem areas had revealed known incipient larval infestations. However, the absence of those infestations in the samples need not indicate that no infestation is present in the tree. The risk ratings are of considerable value in revealing whether or not incipient infestations are present, for a good correlation between risk and the presence of incipient infestations has been found in other work (Bongberg, 1938). For that reason it has been assumed in this report that, in general, the high risk trees stand a good chance of bearing incipient infestations. Some fifteen trees have died on the plot. Cross sections of the boles of those trees have been secured and were available for study. Fourteen of the fifteen infested trees had developed successful flathead borer broods.

The analysis of this material has been along the following lines:

1. Cores from a series of selected representative trees having complete growth complements were measured, averaged and graphed for comparison with published and accepted growth patterns applying to the general area in which Timber Mountain is located.

2. The growth of trees in the four risk groups has been analyzed and graphed, by risks and by decades, to show the growth relations.

3. The growth relations, by risks and decades, have been subjected to statistical analysis to determine the significance of means and differences.

4. Typical illustrations of the growth of trees in the four risk classes have been secured to show similarities or differences in the growth patterns.

5. A study has been made of abnormal growth complements and of the relations of known incipient infestations and abnormal growth patterns.

6. A study has been made of current growth in trees with abnormal growth patterns.

7. A study has been made of the crown and core characteristics of trees.

8. Growth patterns of trees which have died during the period between October 1938 and March 1940 have been analyzed.

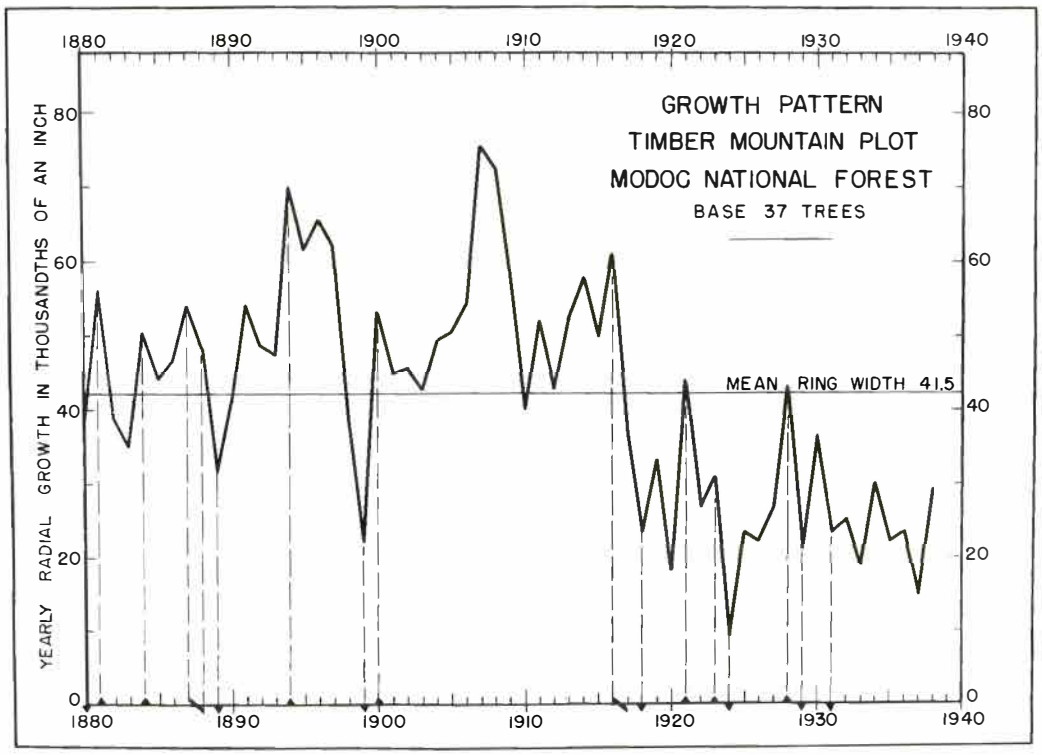


Figure 1.

The growth records from 37 living dominant mature trees of Keen's class 3A were used to determine the normal growth pattern of the Timber Mountain stand from 1880 through 1938. The pattern, with the following minor exceptions is typical of northeastern California growth patterns (Keen, 1937; Anteys, 1938).

1914 instead of 1913 is a wide ring.
1910 instead of 1911 is a narrow ring.
1887, 1888 and 1889 instead of 1886, 1889 and 1890 form a descending growth series.
1884 instead of 1885 is a wide ring.

These exceptions are probably local variations.

Fourteen risk 1, six risk 2, ten risk 3, and seven risk 4 trees constitute the sample.

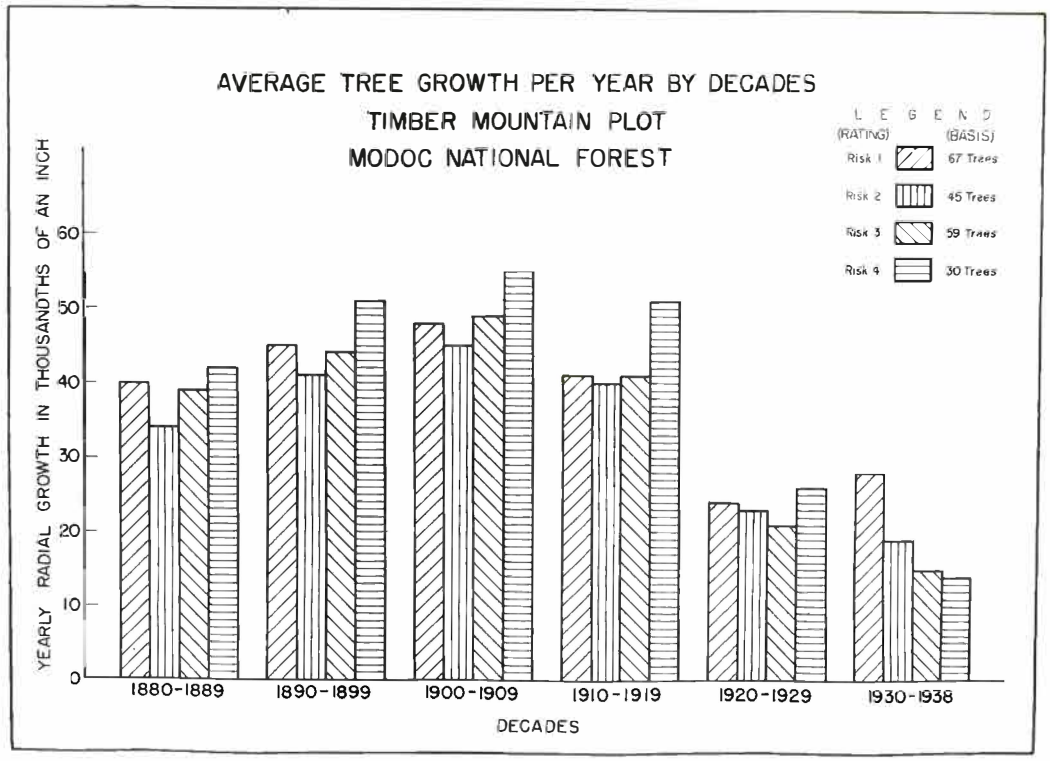


Figure 2

201 trees remained alive on the 40 acres of plot on Timber Mountain in October 1938. Cores were taken from each tree from the north side at breast height. All trees had previously been rated, in August 1936, according to their then current risk.

The cores were all measured, the width of ring for each year being taken. These measurements were segregated by trees into risk groups and decades for the period of 1880 through 1938 inclusive, the last decade being incomplete. Growth per decade was summed and averaged by risks. In cases where missing rings were encountered the total growth was divided by the total number of years in the period rather than the total number of rings of growth.

Figure 2 was constructed from the above data. The same trees constitute the sample throughout the period. The decade averages reflect the growth fluctuations shown in Figure 1. The risks are as of 1936.

The results are as follows: (1) With the exception of the last period, high risk trees were the fastest growing group of the entire sample. (2) In the last or recent decade, growth and risk are inversely related. This relation is different from growth relations of the risk groups in any previous decade. Inasmuch as over one-third of the high risk trees have died since 1936 and about 7 percent of the low risk trees have succumbed in the same period, the results are interpreted as follows.

1. Past growth indicates little concerning the future susceptibility of individual trees.

2. Susceptibility in an individual tree seems to be a condition during a relatively short period of time which may be terminated by death or recovery.

3. Current susceptibility seems to be reflected in an index furnished by the current growth record.

4. Risk has an inverse relation to current growth and thus measures susceptibility.

In order to measure the reliability of the figures for mean growth of each risk group in each decade the standard deviation of the mean was determined. The results are shown in the following table.

ANALYSIS OF MEAN GROWTH BY DECADES AND RISKS

Standard Deviations of Mean Annual Radial Growth
(growth given in thousandths of an inch)

Risks	1		2		3		4		All	
No. Trees	67		45		59		30		201	
Decades	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1880-89	40	±16.90	34	±16.55	39	±18.43	42	±22.36	39	±17.85
1890-99	45	±17.01	41	±25.50	44	±18.55	51	±21.01	45	±19.94
1900-09	48	±18.19	45	±21.97	49	±18.38	55	±24.89	49	±19.91
1910-19	41	±16.91	40	±18.25	41	±18.21	51	±24.71	42	±19.41
1920-29	24	±12.62	23	±11.31	21	±12.51	26	±11.33	23	±12.27
1930-38	28	±20.04	19	±12.28	15	±11.66	14	±11.00	20	±16.08

It is interpreted that the large standard deviation of mean annual growth for all risks in all decades indicates that the growth of individuals in each risk group represents to a considerable extent a cross section of the growth range of the entire sample. Thus it is not even approximately correct to infer that the low risk trees are only the fastest growing ones or that the high risk trees are only the slower growing ones.

SIGNIFICANCE OF DIFFERENCES BETWEEN MEANS

Values for the significance of differences between means were determined and read from Fisher's (1928) table for t. Values in excess of 1.95996 (P = .05) were considered significant. The following results were secured.

Significance of Differences between Means of Annual Growth

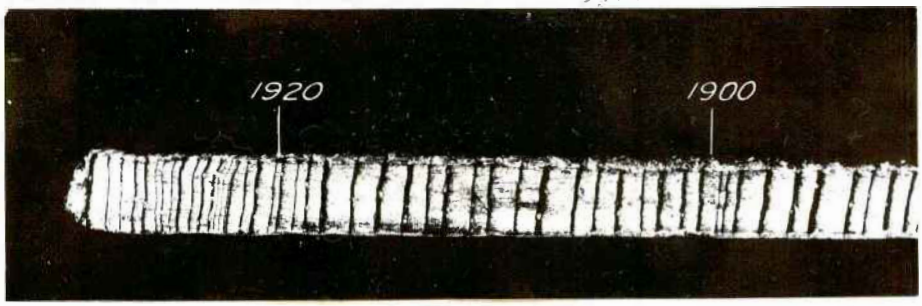
Decades	1880-89	1890-99	1900-09	1910-19	1920-29	1930-38
Difference between Risks	Values of t					
1 and 2	1.86	.92	.82	.29	.44	2.94
1 and 3	.31	.31	29	.00	1.35	4.51
1 and 4	.22	1.37	1.36	2.01	.77	4.43
2 and 3	1.48	.59	1.11	.28	.86	1.65
2 and 4	1.68	1.85	1.89	2.09	1.12	1.84
3 and 4	.63	1.54	1.17	1.96	1.91	.40

In the decades preceding that of 1930-38 several differences between means approach significance. In the decade 1910-19 the differences between risks 1 and 4, 2 and 4, and 3 and 4 are significant, risk 4 having the larger mean. However, through the 50 year period there does not seem to be evidence that any group of trees, which were classed as of a certain risk in 1936 had any static growth difference relative to the growth of trees in other risks.

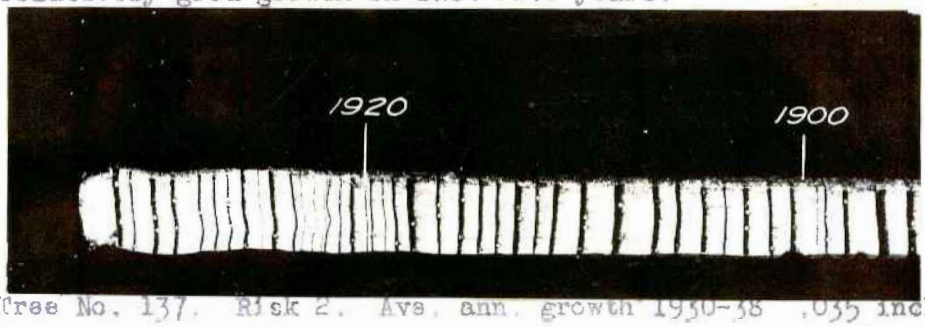
In the last period (1930-38) when a reversal of means occurred, highly significant differences occurred between the means of 1 and 2, 1 and 3, 1 and 4, indicating that in terms of growth the risk 1 group is the only group having a mean significantly different from that of the other risk groups. Differences between risks 2 and 3, and 2 and 4 approach a significant figure. It seems worthy of comment that the difference between the means of risks 3 and 4 show a very low t value.

ILLUSTRATIONS OF GROWTH PATTERNS IN THE FOUR RISK CLASSES

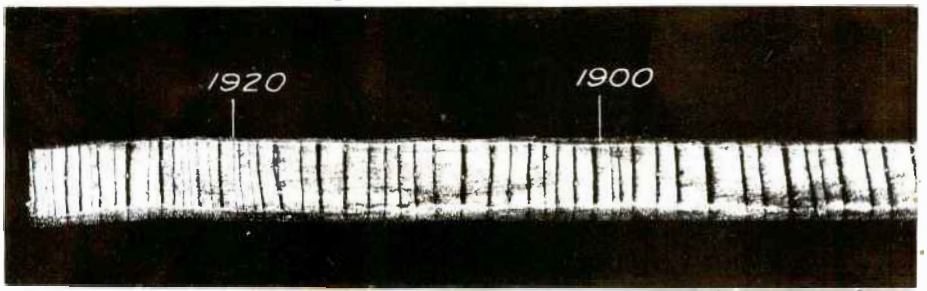
In order to illustrate the normality of patterns of growth regardless of risk, typical trees having complete growth patterns were selected in each risk class. All cores taken in October 1938.



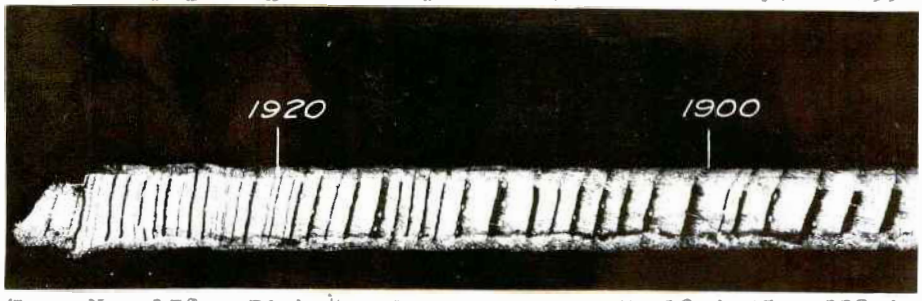
Tree No. 774. Risk 1. Ave. ann growth 1930-38 .026 inches.
Note relatively good growth in last five years.



Tree No. 137. Risk 2. Ave. ann. growth 1930-38 .035 inches.
Note typical key years, good growth record and small 1937 ring. No other tree used as an example here shows as narrow a 1937 ring.



Tree No 557. Risk 3 Ave. ann growth 1930-38 .029 inches
Note relatively good growth in past 10 years with 1937 & 1933 narrower.



Tree No 159 Risk 4. Ave. ann growth 1930-38 .022 inches.
Note last two rings and 1933 ring narrower Typical of high risk trees.

All cores shown on page 6 are from mature, dominant trees in Keen's class 3A. Trees numbered 774 and 137 are 20 inches in diameter, while 557 and 159 are 22 inches in diameter breast height.

It should be noted that the average annual growth during the decade 1930-38 corresponds in general to the differences between risk classes as illustrated in Figure 2. The figures for all decades for these individual trees are given in the following table.

Average Annual Growth (in inches) of
Individual Examples of the Four Risk Classes

Tree No. & Risk	774 (R.1)	137 (R.2)	557 (R.3)	159 (R.4)
Decades				
1930-38	.062	.035	.029	.022
1920-29	.019	.024	.021	.020
1910-19	.047	.040	.039	.056
1900-09	.052	.059	.045	.064
1890-99	.045	.049	.048	.075
1880-89	.031	.033	.049	.069

ABNORMAL GROWTH PATTERNS

Not all trees in the 201 tree sample from Timber Mountain had complete growth complements. The following table gives the details secured from a microscopic examination of cores from the entire 201 trees which were green and presumably living in October 1938.

Tendency for Abnormal Growth Patterns as Indicated by
Cores Taken from Breast Height on the North Side of Each Tree

Risk Class	No. Trees in Sample	Number of Trees with Missing Rings					
		1930-38		1920-29		Total 1920-38	
		No. trees	% sample	No. trees	% sample	No. trees	% sample
1	67	9	13.4	3	4.5	12	17.9
2	45	6	13.3	1	2.2	7	15.5
3	59	27	45.8	6	10.2	28	47.4
4	30	13	43.4	2	6.7	14	46.6
Tot. and Averages	201	55	27.4	12	6.0	61	30.4

So far as could be determined, but one sample showed rings were missing in the decades before 1920. The last 19 years constituted a period of tension during which growth of the trees has been affected greatly by extreme environmental conditions.

In connection with the above table it is interesting to note the relation existing between the percent of trees known to bear incipient infestations in galleries and incomplete complements and the percent of trees in each risk class having incomplete complements.

Risk	% of trees with incipient galleries and incomplete complements	Ratio*
1	7	.39
2	22	1.42
3	44	.93
4	54	1.16
All trees	32	1.05

* Ratio secured by dividing the percent of trees with incomplete complements in group with incipient galleries by the percent of trees with incomplete complements in each risk class.

Incomplete complements occurred less often in trees known to bear incipient infestations in risks 1 and 3, and more often in risks 2 and 4.

CURRENT GROWTH IN TREES WITH ABNORMAL PATTERNS

In order to determine if missing rings were accompanied by a lack of subsequent growth the 1938 cores were supplemented by a second series of cores taken in March 1940 from the same trees, and from a nearby portion of the bole. These cores should show a 1939 ring if growth had occurred in that year.

Of the 61 trees exhibiting abnormal growth patterns, no second core was secured from 5 trees. Ten of the total number died during the period of 1938-40 and no second core was taken. No second core was secured from the six trees in which the abnormality in growth occurred only during the 1920-29 decade and in which subsequent growth in the 1938 core was found to be normal. Paired cores were secured from 40 trees distributed as follows in the risk classes.

Risk	No Trees
1	8
2	6
3	21
4	5
Total	40

Examination under a microscope showed that the following conditions obtained in these 40 pairs of cores.

Risk	Additional Rings Present	No Additional Rings Present
1	8	0
2	6	0
3	12	9
4	5	0
Totals	31	9

It is to be concluded that over 77 percent of the trees are continuing growth, In many cases it is impossible to state definitely and with complete assurance on the basis of the sample taken which year or years of growth are missing. However, it is my opinion as a result of microscopic examination and comparisons that in most cases growth of the years 1938 and 1939 is present and that ring growth failed or was partial at the point at which the cores were taken mostly during the years 1933, 1935 and 1937 in addition to 1924 in the decade 1920-29.

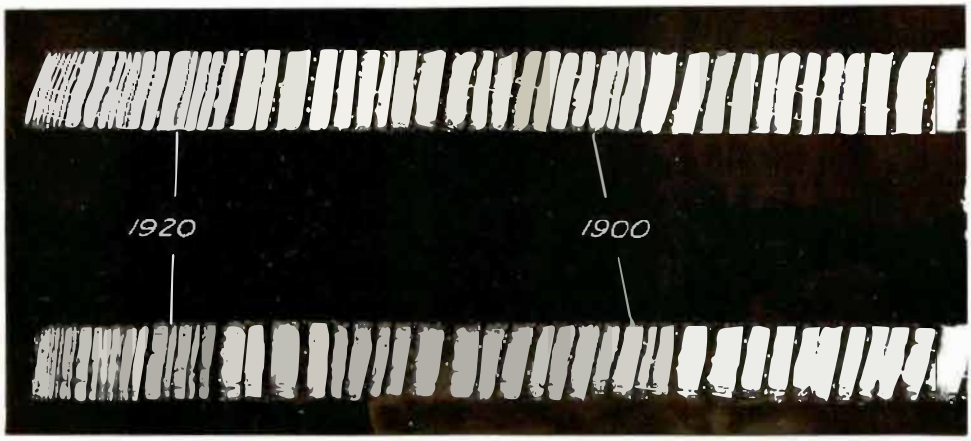
In August 1936 well over half of the trees on the Timber Mountain plots were considered likely to contain incipient flathead broods. A comparison of the records taken at that time was made to determine if trees in which missing rings were found in 1938 and 1939 were predominantly those in which living incipient flathead broods actually were found in the small basal samples that were examined in 1936. The following results were secured from that analysis.

Risk	Trees in which living incipient broods were found	
	With complete complement through 1938	With incomplete complement through 1938
1	3	1
2	12	2
3	11	4
4	7	4

Of the eleven trees in which larvae were found, but in which an incomplete complement was shown by the 1938 cores, in one case no 1939 core had been taken. One 1939 core had no additional rings and 9 showed the presence of additional rings, or current growth.

Study of Paired Cores.

The following illustrations show cores in which additional growth was found in a second core taken from the same tree a year and a half after the first core was secured. Upper core taken March 1940, lower October 1938.

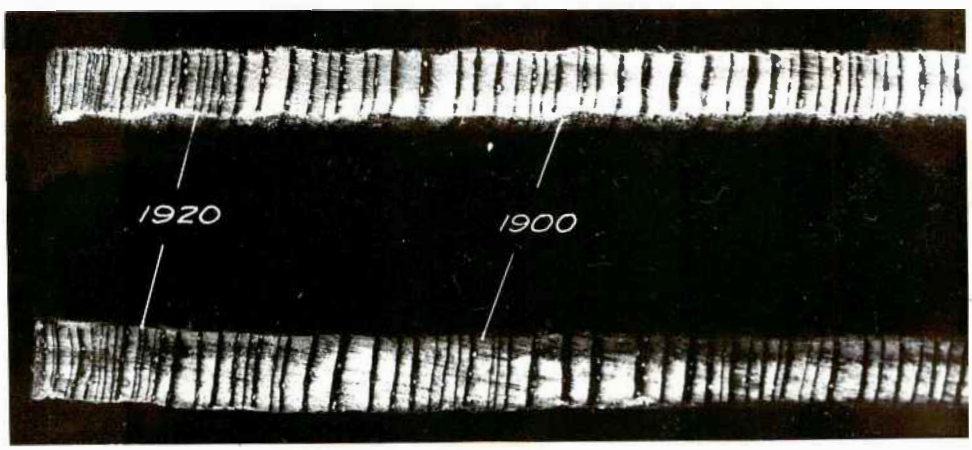


Tree 816. Risk 4. DBH 18".
Rings after 1930. 1938 core - 6.

Apparently 1933 ring and one other missing. Last (outer) ring with FH incipient gallery distorting wood of apparently the 1938 ring.

1940 core - 8

One ring, possibly the 1935 missing. 1933 very narrow, barely visible in picture. Recovery of growth evident 1936-1939



Tree 1001. Risk 1. DBH 26"
Rings after 1930 1938 core - 6

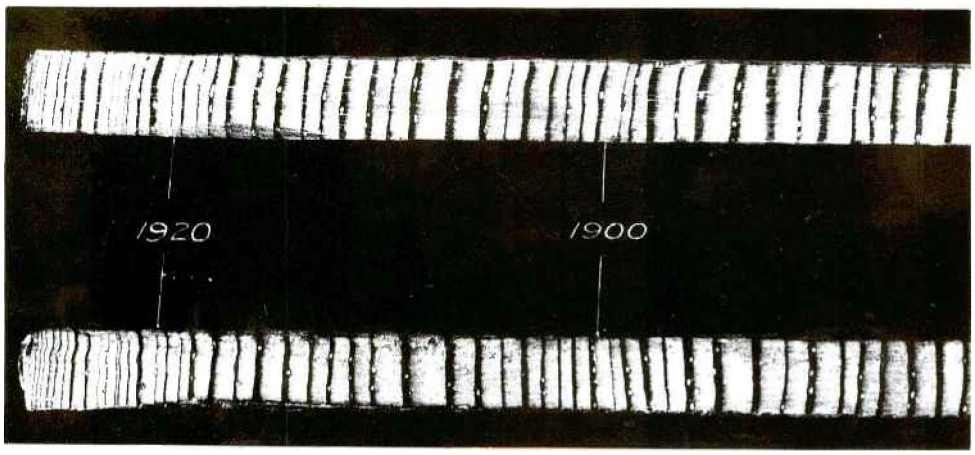
Marked decrease in growth since 1930. Not possible to state definitely just which rings are missing in this core.

1940 core - 8

Growth recovered after 1935 with normal narrower 1937 ring. I believe 1933 ring is the one missing.

Study of Paired Cores

Upper core in each figure taken in March 1940, lower in October 1938

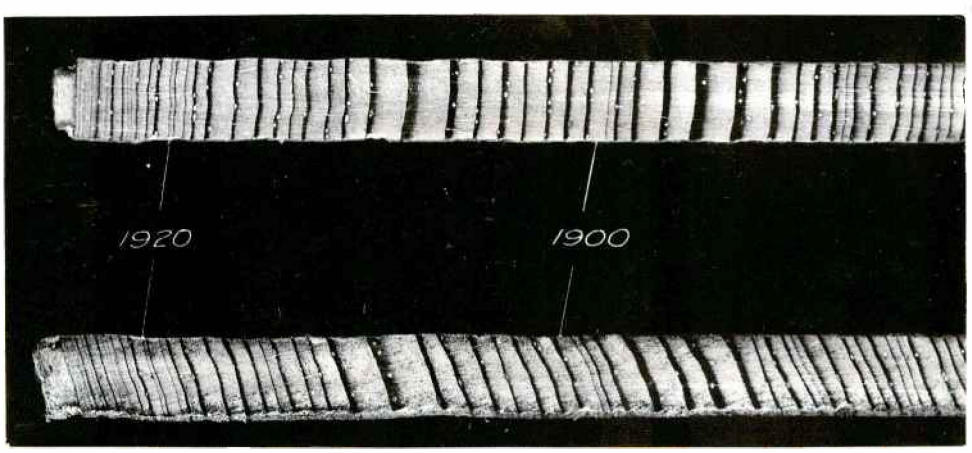


Tree 1286. Risk 3. DBH 26".
Rings after 1930 1938 core - 6

With the exception of narrow next to last ring, growth is complacent since 1930. If 1933 and 1935 rings actually are missing the full complement is accounted for.

1940 core - 7

The record of 1936-1939 growth is typical. Thus it is indicated that the 1933 and 1935 rings are missing.



Tree 1452. Risk 3. DBH 32".
Rings after 1930 1938 core - 6.
1940 core - 7

Both cores show the same pattern after 1930 in the following sequence: 1930 ring then narrow, wide, narrow, wide, narrow, wide. In the 1940 core an additional wide ring occurs at the end. This may be interpreted as the 1939 ring if 1933 and 1935 are missing. That pattern would be close to that occurring in some full complement trees

On the basis of these data and from these samples, it can be concluded that:

1. Abnormal growth complements occur in all risk groups.

2. There is a tendency for abnormal complements to occur more often in the higher risk groups.

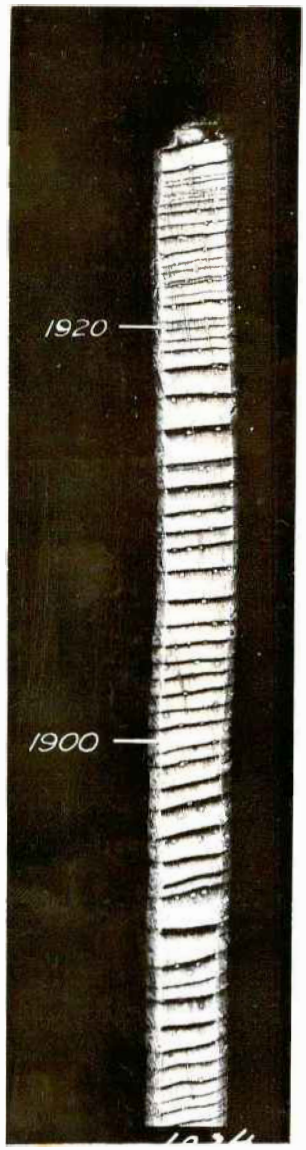
3. However, most of the trees having abnormal complements show evidence of current growth.

4. The years 1924, 1933, 1935 and 1937 are the ones which tend to drop out or have partial rings. These are the years in which growth in trees with full complements has been found to be in narrow rings.

5. Incipient flathead infestations did not occur primarily in those trees which later have been found to have abnormal growth patterns.

CROWN AND CORE CHARACTERISTICS OF TREES

A series of pictures has been taken of various trees located in the Timber Mountain plot and of cores taken from those trees. The trees had been rated according to risk. In some the risk has changed during the period of record. The purpose of the series is to determine if certain diameter growth conditions can be definitely linked with certain crown characteristics.



Tree Number 1034

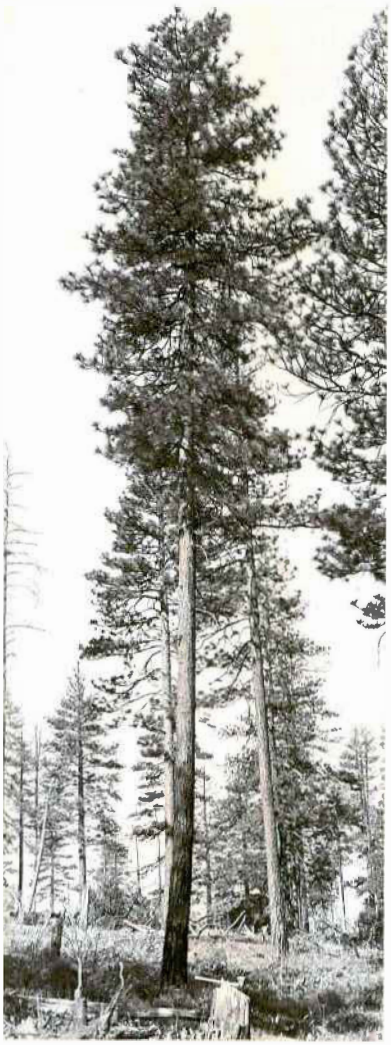
Risk: August 1936 1; September 1939 - 1.

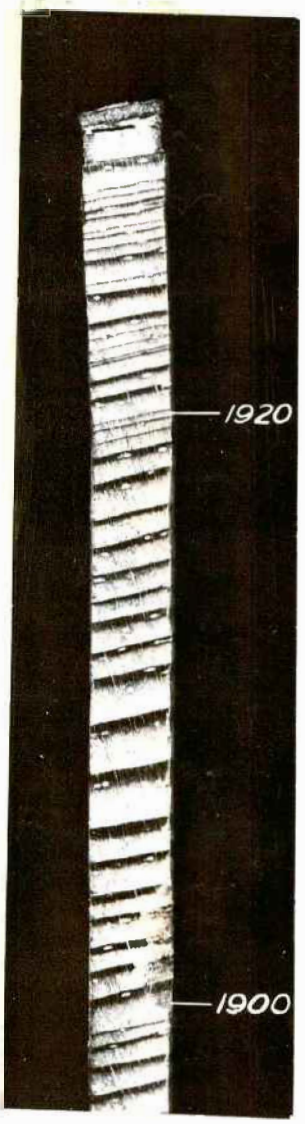
Diameter: 18".

Crown Characteristics: Dense needle complement; long, dark colored needles; no to light twig injury; no branch injury

Core Characteristics: Core taken March 1940. Growth to 1920 good; generally less to 1938; 1939 ring wide, showing recovery. 1 ring missing between 1930 and 1936.

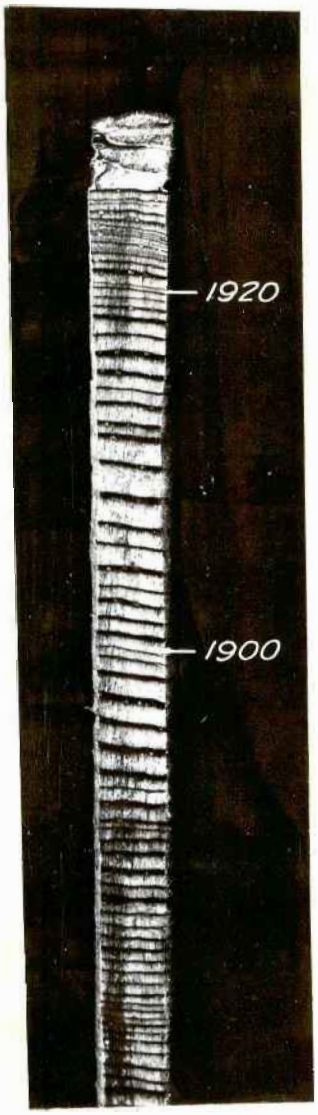
Risk 1





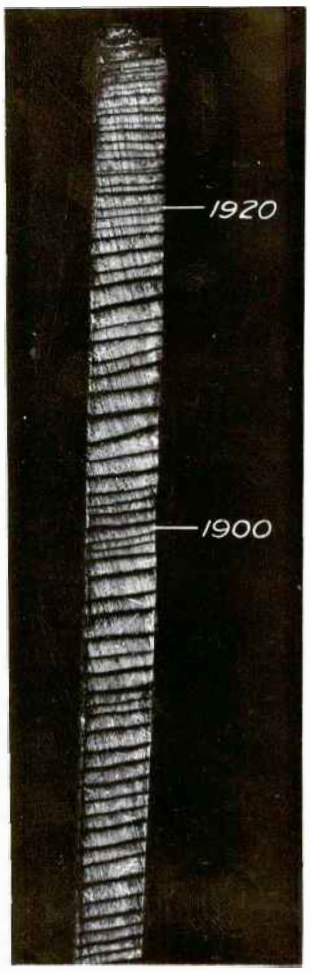
Tree Number 1207
Risk: August 1936 - 1; September 1939 - 1.
Diameter: 18"
Crown Characteristics: Dense needle complement; medium length needles; color dark green; no to light twig injury; no branch injury.
Core Characteristics: Core taken October 1938. Growth good and responsive throughout. 1938 ring wide showing recovery. Complement complete.

Risk 1

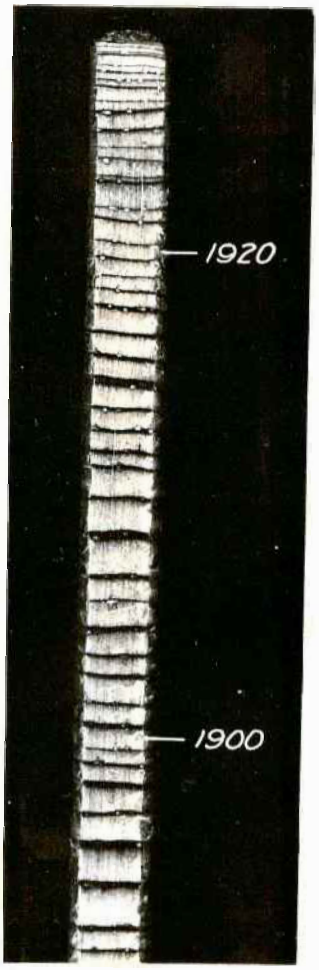


Tree Number 1209.
Risk: August 1936 - 1, September 1939 - 1.
Diameter: 16".
Crown Characteristics: Medium needle complement; medium needle length; color dark green; no twig injury; no branch injury.
Core Characteristics: Core taken October 1938. Growth good to fair through 1923. 1924 ring missing. Growth thereafter complete, but most rings narrow. 1935, '36, '37 and '38 growth showing some recovery.

Risk 1



Tree Number 1169.
Risk: August 1936 - 1; September 1939 - 2.
Diameter: 14".
Crown Characteristics: Medium needle complement; medium needle length; color dark green; light twig injury; no to light branch injury.
Core Characteristics: Core taken October 1938. Growth somewhat better than fair through 1923. Fair to poor thereafter. Complete complement. No recovery in last few years.



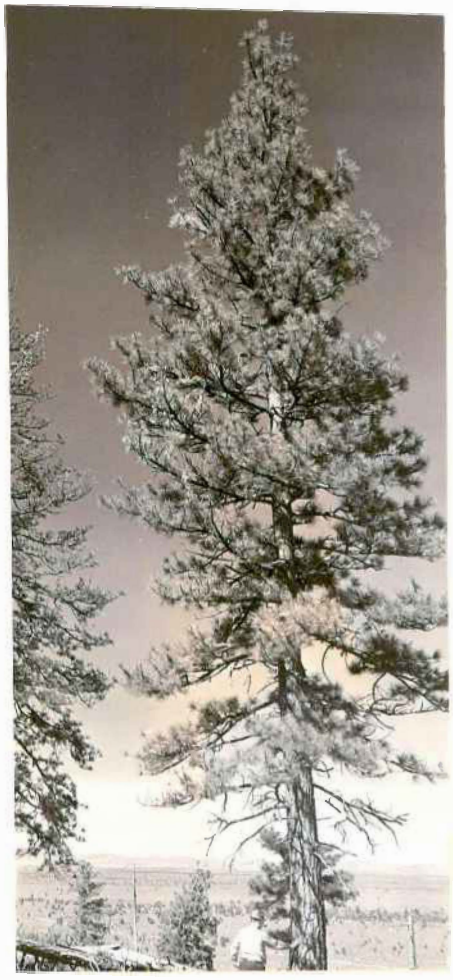
Tree Number 1307
Risk: August 1936 - 4; September 1939 - 4.
Diameter: 22".
Crown Characteristics

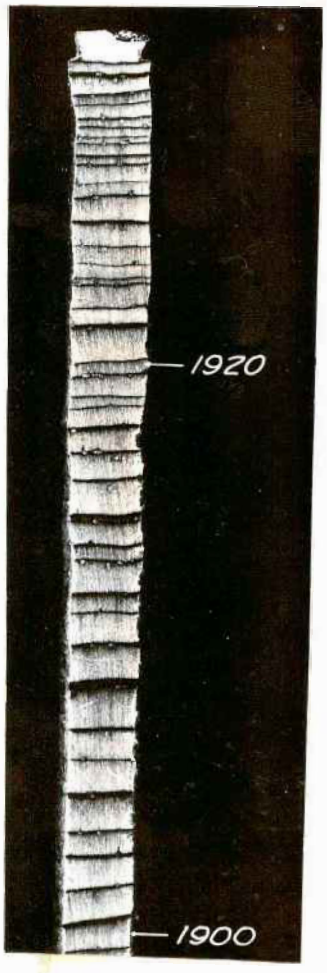
	1936	1939
Needle complement	Medium	thin
Needle length	medium	short
Needle color	light	light
Twig injury	light	light
Branch injury	light	light

1939 needle growth good. Aspidiotus and Chionaspis scales noted on needles during 1939 and 1940

Core Characteristics. Core taken March 1940. Growth good through 1934 but poorer after 1930. Complement complete but 1937 ring partial and very narrow; 1939 ring with very small amount of spring wood only.

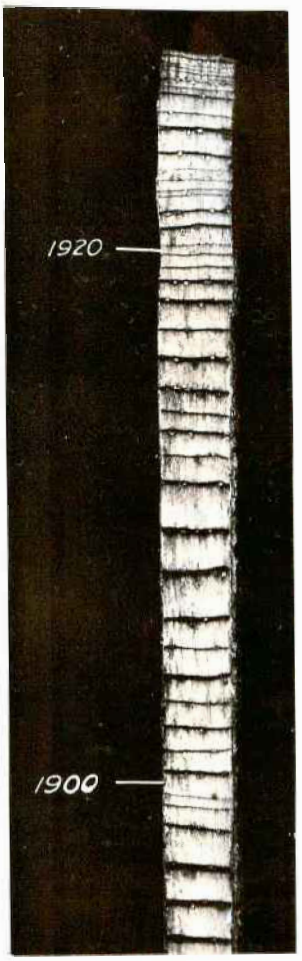
Risk 1





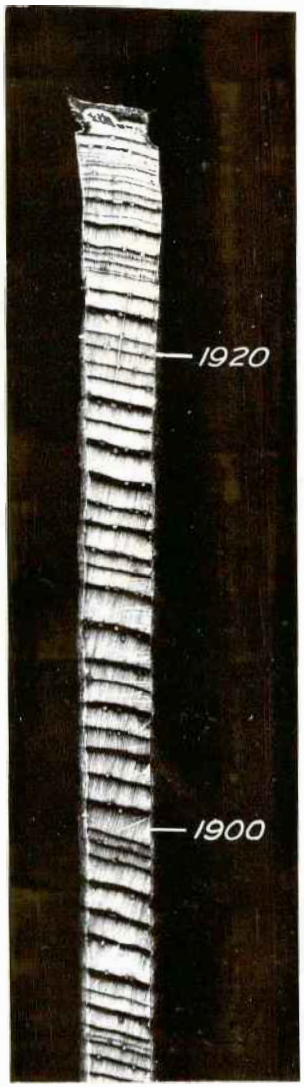
Tree Number 1312.
Risk: August 1936 - 1; September 1939 - 2.
Diameter: 20".
Crown Characteristics: Needle complement medium to dense; needle length medium; needle color dark; twig injury light; branch injury none.
Core Characteristics: Core taken March 1940. Growth good throughout with responsive pattern.

Risk 2



Tree Number 870.
Risk: August 1936 - 2; September 1939 - 3.
Diameter: 28"
Crown Characteristics: Needle complement thin to medium; needle length short to medium; needle color light; twig injury light; branch injury light.
Core Characteristics: Core taken March 1940. Growth through 1930 good, 1930 through 1932 fair and beyond 1932 poor. 1937 ring almost missing it is so narrow, may be only partial. Otherwise complement complete.

Risk 2



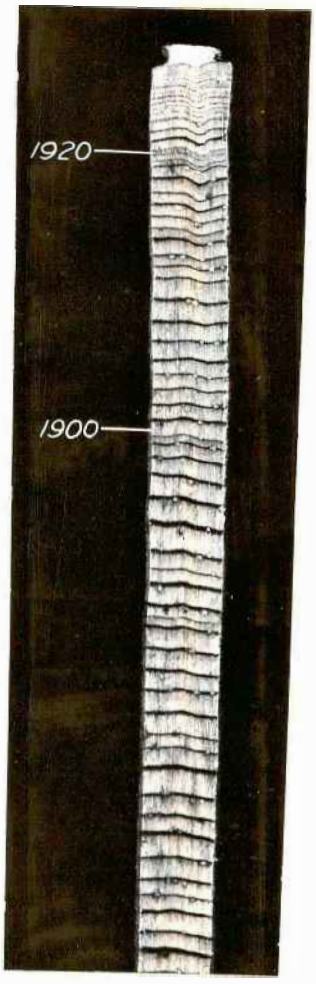
Tree Number 1474.
Risk: August 1936 - 2; September 1937 - 4; September 1938 - 3; September 1939 - 2.

Diameter: 12".

Crown Characteristics. Needle complement medium; needle length medium to long; color dark green; twig injury moderate; branch injury moderate. Topkill first noted in June 1938.

Core Characteristics. Core taken in March 1940. Growth fairly good through 1930; fair from 1930 through 1934; poor through 1937 and becoming much better in 1938 and 1939. Complement complete. Apparently top-kill injury was followed by a recovery.

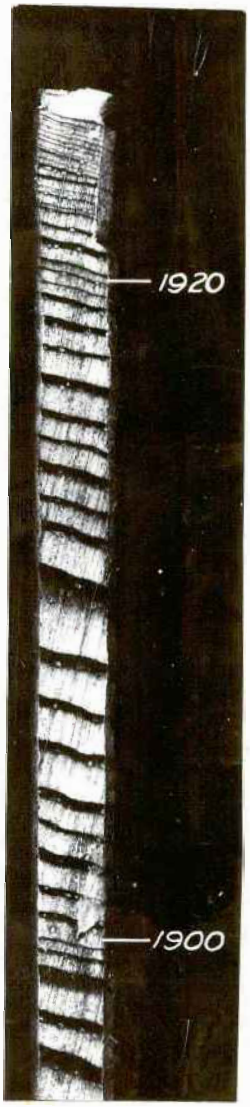
Risk 5



Tree Number 1168.
Risk: August 1936 - 5, September 1939 - 4.
Diameter: 26".
Crown Characteristics: Needle complement thin to medium; needle length medium; needle color light green; twig injury severe, concentrated in portion of upper crown, branch injury moderate to severe

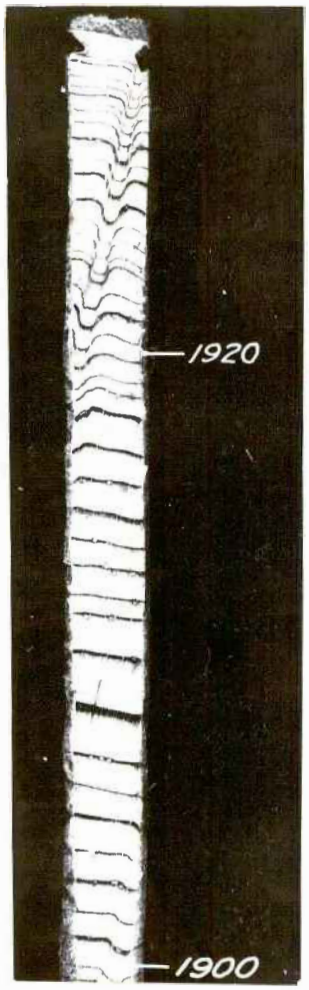
Core Characteristics: Core taken in March 1940. Good to fair through 1923, rings narrow 1923 on. Complement lacks two rings, probably 1937 and 1933. Growth from 1923 on fairly even and unresponsive. No recovery evident in last year or two.

Risk 3



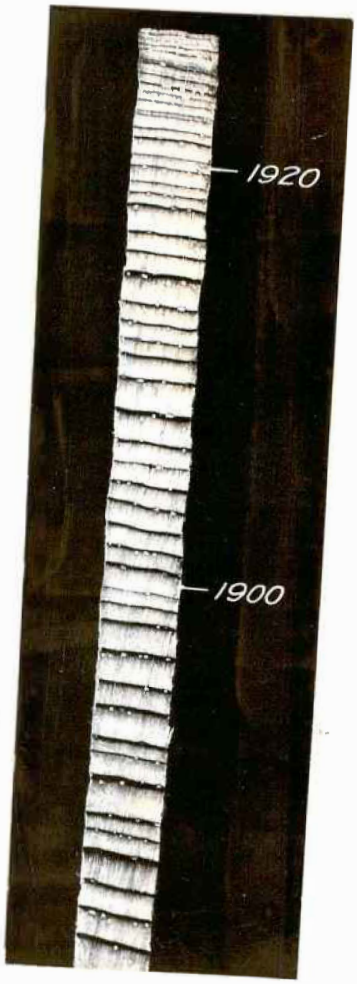
Tree Number 1208.
Risk: August 1936 - 3; September 1939 - 3 plus
Diameter: 16".
Crown Characteristics: Needle complement thin to medium; needle length short to medium; needle color light green; twig injury light; branch injury light.
Core Characteristics Core taken in October 1938. Growth good through 1923, fair through 1930 and poor through 1938. Complement complete.

Risk 3

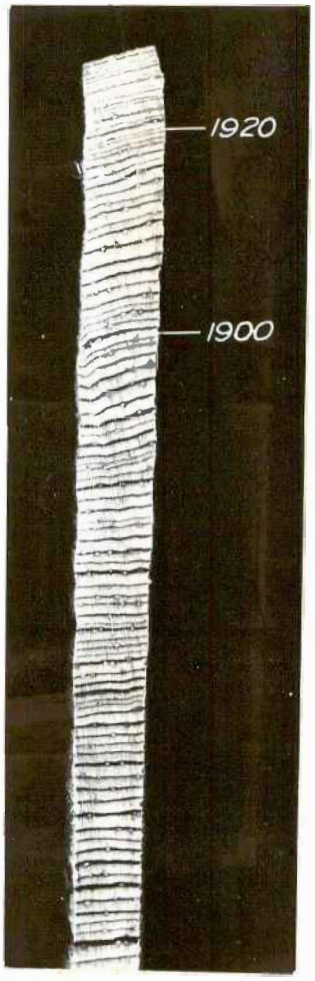


Tree Number 1306.
Risk: August 1936 - 3; September 1939 - 4.
Diameter: 26".
Crown Characteristics: Needle complement thin to medium; needle length short to medium; needle color light; twig injury severe; branch injury severe. Topkill occurred during 1938 with additional subsequent kill in 1939.
Core Characteristics: Core taken in March 1940. Growth good through 1932, fairly good to 1939 but narrower rings. Complement complete and responsive.

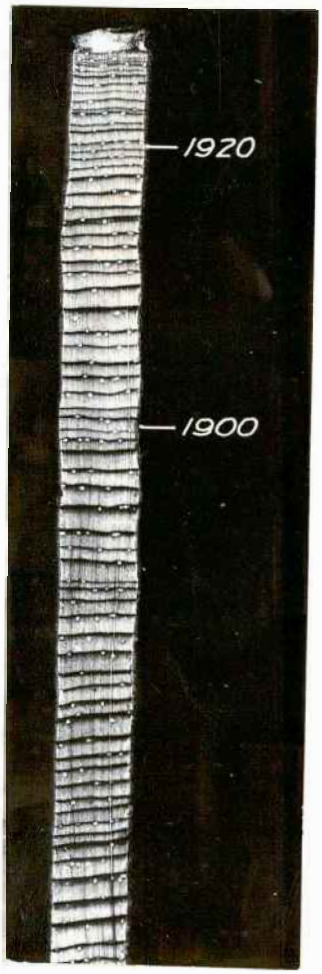
Risk 3



Tree Number 1311.
Risk: August 1936 - 3; September 1939 - 4.
Diameter: 24".
Crown Characteristics: Needle complement thin to medium; needle length short to medium, needle color light green; twig injury severe; branch injury moderate. Topkill appeared in 1937.
Core Characteristics: Core taken in March 1940. Growth good through 1930, fair to poor to 1939. Growth complement complete with three narrow rings representing years 1931, '32, and '33.



Tree Number 1170.
Risk: August 1936 - 4; September 1939 - 4.
Diameter: 24".
Crown Characteristics: Needle complement thin; needle length medium; needle color light green; twig injury severe; branch injury moderate to severe.
Core Characteristics: Core taken in March 1940. Growth good through 1917, fair through 1930, narrowing down after that time. Last three rings appear to be the 1937, '38, '39 series but one ring, probably the 1933, apparently missing between 1930 and 1939.

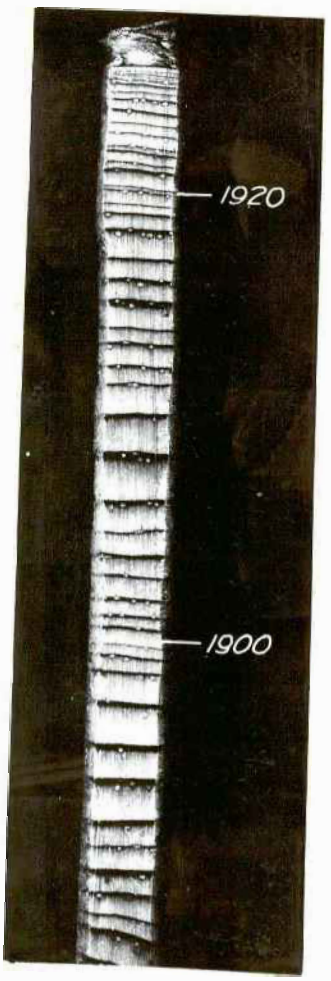


Tree Number 1310.
Risk: August 1936 - 4; September 1939 - 4.
Diameter: 24".

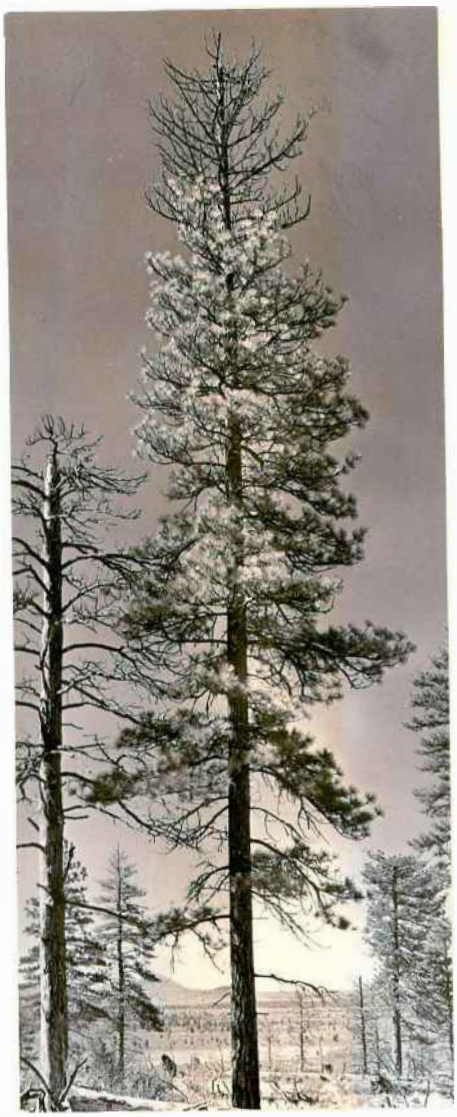
Crown Characteristics: Needle complement thin; needle length medium; needle color light green; twig injury severe; branch injury moderate to severe. 1939 needle growth a little short. Chionaspis and Aspidiotus present on needles in last two years.

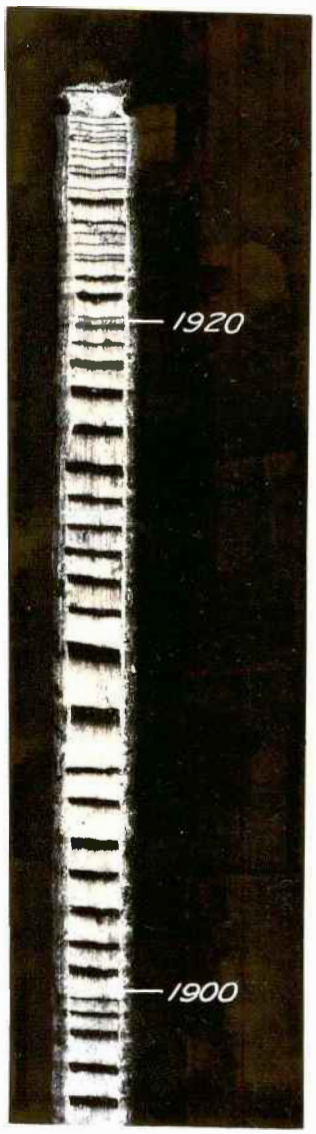
Core Characteristics: Core taken in March 1940. Growth fairly good through 1930, much poorer from then on. 1933 ring very narrow, two rings missing between 1930 and 1939. It is impossible to tell which are missing. The last ring is small and but a lense of growth.

Risk 4



Tree Number 1457.
Risk: August 1936 4; September 1939 - 4.
Diameter: 24".
Crown Characteristics: Needle complement thin to medium, needle length short; needle color light green; twig injury moderate; branch injury light. Very small top kill occurred in 1938.
Core Characteristics: Core taken in March 1940. Growth good through 1930, poor from then on. But six rings present beyond 1930 where nine should occur. The last ring is wide and may be 1939 growth, but the pattern in between 1931 and 1939 is almost impossible to decipher.





Tree Number 1475
Risk: August 1936 - 4; September 1934 - 4
Diameter: 20".
Crown Characteristics: Needle complement thin to medium; needle length short to medium; needle color yellow; twig injury severe; branch injury severe. Top kill occurred in 1938 with subsequent killing now going on.
Core Characteristics: Core taken in March 1940. Growth good through 1930 and fair to end of core. Complete ring complement with 1937 ring narrow in typical fashion

The previously noted facts that high risk trees tend to have slower recent growth and incomplete complements are borne out by the examples used in this section. There seems to be little relation between any of the characteristics used in rating risk and any typical growth pattern or abnormality. Trees 1169, 1307, 1312, 1306, 1311, 1170, 1310, 1457 and 1475 were found to have incipient infestations in 1936. Six of these nine trees have been found to have complete complements. Thus this evidence indicates that a lack of current growth does not seem to be a requirement for the occurrence of incipient infestations.

PRESENCE OF INCIPIENTS IN GREEN AND INFESTED TREES

In the entire stand which was present on the 40-acre plot area in 1936 several interesting points have been found concerning the presence of incipient flathead galleries in green trees and subsequent infestation and death. This information is summarized in the following table.

Risk	1	2	3	4	Entire Stand
Total number trees, 1936	68	48	65	57	238*
Trees without incipients, 1936	52	23	30	11	116
Trees with incipients, 1936	16	25	35	46	122
% trees with incipients, 1936	23.5	52.1	53.9	80.7	51.3
No. trees killed since 1936	2	7	13	38	60
% of class killed	2.9	14.6	20.0	66.7	25.2
Ratio of loss, by risks to loss in entire stand	.115	.579	.793	2.65	
Number trees infested which had incipients in 1936	2	6	10	30	48
% of occurrence of incipients in infested trees	100.0	85.7	77.0	79.0	80.0
Ratio of occurrence in infested trees to occurrence of incip. in class	4.26	1.64	1.43	.99	1.56

* Discrepancy between 1936 stand figures less insect caused mortality and 1938 stand figure (201 trees) is accounted for by including 15 trees killed since 1938 and 8 trees felled by loggers in 1939 in the above table.

This table shows that the high risk trees predominate in the loss record. Also that incipient infestations occurred in the risk 4 class approximately as they occurred in the loss in that class. However, it also is shown for the other risk classes and for the stand as a whole that they occurred more often in the trees subsequently infested than they did in the stand as a whole and that the selection of trees in the

low risk classes became more predominantly a selection of those trees in which incipients occur.

Incipient infestations preceded death in 80 percent of the infested trees. However, flathead borer broods were produced in 53 of the 60 trees that died or in 88.5 percent of the infested trees.

GROWTH PATTERNS OF INFESTED TREES.

Since October 1938, 15 trees have become infested on the Timber Mountain plot. All of these trees have been felled, analyzed for the composition of infestation and cross sections have been cut at various heights on the boles. These cross sections have been studied under a microscope to determine which was the last year in which growth can be considered to occur. The comparison is made to determine if the trees probably died and stopped growing before the inception of the fast growing stage of the flathead larvae or if growth continued up to that time. The following table lists the results of that examination. Of necessity it cannot be claimed that, in all cases, the interpretation is strictly accurate because of the difficulty of determining which ring represents which year of growth, particularly in trees in which rings previous to the current ones are missing. However, as stated before, it is believed that in most trees with abnormal patterns current growth occurred and that the years 1933, 1935 and 1937 which normally are narrow rings are usually the missing rings.

RESULTS OF EXAMINATIONS OF CROSS SECTIONS OF INFESTED TREES

Tree Number	Height on Bole	Insect Species	Brood	Last Expected Growth	Last Growth Found Quadrant			
					N	E	S	W
101	2	FH-DB-IO	39S	38	--	38	37(1)	--
	30				38	39	39	39
	60				39	38	38	38
112	2	FH-IO	38W	37	37	36	36	37
	20				36	37	37	37
	40				37	37	37	37
	60				37	37	36	36
116	2	FH-DB	39S	38	37	38	38	38
	30				38	38	38	38
	60				36	37	38	35
176	2	TK-FH-IO	39W	38	38	38	38	38
	30				38	38	38	38
	65				37	38	38	37
	70 (old topkill)				37	35	36	36
304	2	FH	39W	38	38	37	38	38
	20				39	39	39(?)	39(?)
373	2	FH-DB	38S&W	37	36	36	37	37
	20				37	38	38	38
	40				37	37	37	37
	60				37	37	37	37
435	2	FH	39W	38	38	38	37	38
	35				39	39	39	39
438	2	FH	39W	38	39	39	39	39
597	2	FH-DB	39S&W	38	38	39	39	39
	32				39	39	39	39
808	2	FH	38W	37	38	37	38	38
	15				38	38	38	38
	30				38	38	38	38
947	2	FH	39W	38	38	38	38	37
	40				39	39	39	39
1531	2	Misc.	39W	38	39	39	38	39
	25				38	38	39	39

Poor or no current growth indicated.

111	2	FH	39W	38	36	35	37	36
	30				35	36	35	36
	60				35	34	35	35
381	30	FH	39W	38	36	37	37	37
	45				38	38	38	38
	58(S.Fk)				37	37	37	38
	58(N.Fk)				32	32	37	33
1333	2	FH	39W	38	31	34	38	34
	30				38	39	38	39

(1) It is believed the last ring actually is the 1938 ring and that the 1937 ring is missing.

Observations made during the analyses of growth in cross sections of infested trees indicated that incipient larvae tended to occur less frequently in the basal sections in which a larger proportion of growth deficiencies were observed. However, it is also my observation, due to the considerable total number of partial or missing rings in the samples in years previous to the last ring, and to the slowness of some of the growth, that perhaps some of the deficiencies may be apparent rather than actual. The majority of the samples seem to indicate that growth continued practically up to the season of the inception of the fast growing larval stage and that the incipient stage occurred in growing trees.

CONCLUSIONS

The question to be answered by this study was whether trees bearing incipient brood infestations of the flathead borer (M. californica VD) are growing and thus living trees or whether growth has ceased and egg laying by adult beetles and larval attacks follow in trees which actually are dead.

The preponderance of evidence points to the conclusion that most of the trees in which incipient infestations occur are growing and thus may be considered as living trees.

In addition, the following conclusions have been reached:

1. The types of trees in which most of the loss has been recorded, i.e., high risk trees, are generally the slower growing ones.

2. The slow growth rate is of recent origin and probably temporary, to be terminated either by death or recovery.

3. Growth abnormalities tend to occur more often in the high risk trees.

4. Current growth is occurring in most of the trees in which abnormalities have been found in the growth pattern.

5. The majority of trees in which incipient infestations were found in 1936 later proved to have complete growth complements through 1938.

6. No apparent relation was found between crown characters used in rating risk and any particular type of growth pattern.

7. Incipient infestations tended to occur more often in the trees which subsequently died than they did in the stand as a whole.

8. Most of the trees which have died on the Timber Mountain plot between October 1938 and March 1940 seem to have been putting on growth up to the season during which the inception of the fast growing larval stage occurred.

These conclusions have been drawn from data secured from a 201 tree sample taken from an area located at Timber Mountain in the Modoc National Forest. This area was selected in conformance to and in agreement with the principles for selection of ecological study areas described by Taylor (1934).

ACKNOWLEDGEMENTS

The field work involved in this study has had the attention of several of the men who have worked or are now working at this laboratory. The list includes A. S. West, Jr., J. W. Bongberg, C. B. Eaton, R. C. Hall and J. W. Johnson. A. A. Hasel and D. Dunning of the California Forest and Range Experiment Station have contributed suggestions for the statistical analysis of the data. S. T. Carlson assisted in the analysis of growth in infested trees. P. C. Johnson marked and lettered and N. D. Wygant printed the illustrations. The aid of all these men, and of others who have contributed ideas and suggestions is hereby acknowledged.

REFERENCES

1. Antevs, Ernst. 1938
Rainfall and Tree Growth in the Great Basin. Carnegie Inst. of Wash. Pub. No. 469; and Amer. Geo. Soc. of N. Y., Special Pub. No. 21, pp 1-95, 7 text figures, 2 plates.

2. Bongberg, J. W. 1938
Tree Susceptibility Studies in Black's Mountain Experimental Forest, A Progress Report. Feb. 26. (Unpublished)

3. Fisher, R. A. 1928
Statistical Methods for Research Workers. 2nd Ed. 269 pp. Edinburgh, London.

4. Keen, F. P. 1937
Climatic Cycles in Eastern Oregon as Indicated by Tree Rings. Mo. Weather Rev. 65:175-188. May.

5. Taylor, W. P. 1934
Significance of Extreme or Intermittent Conditions in Distribution of Species and Management of Natural Resources, with a Restatement of Liebig's Law of Minimum. Ecology, V.5:(1) 374-379.

D Hildebrand Repro

MEMORANDUM FOR MR. J. M. MILLER.

Reference is made to Dr. Craighead's letter to you of October 15, 1940, containing comments on and criticisms of the report "A Preliminary Study of the Diameter Growth of Ponderosa Pine ... etc."

I find many statements in that letter with which I heartily agree, in fact some of them restate the impressions I hoped to convey. However, I cannot follow some of Dr. Craighead's reasoning or the lines of thought by which he advances from factual statements with which I agree to conclusions that are quite different from those I reached. Perhaps one of the reasons for that diversity of opinion concerning the interpretation of the results is that Dr. Craighead looks at this flathead problem from the general viewpoint of wide experience with other flathead borers and interprets this problem in the light of knowledge concerning them. My viewpoint is, of course, confined to a reading knowledge of those backgrounds and is based chiefly on an intimate knowledge of this specific problem in the area in which the research work has been done. To my mind, the preponderance of evidence points to differences that make the behavior pattern of the species with which I have been working different from that generally attributed to flathead borers.

Disagreement as to interpretation of results is, of course, not new in this line of research. I have found it stimulating in some respects. However, I have to admit that at times I have been somewhat discouraged by the tone that has characterized some of the criticism.

Specific information that may aid Dr. Craighead in further appraising the results of the research project covered by the report is as follows:

Page 2, paragraph 4: Table I attached shows that the standard deviations for the last decade are proportionately larger than those of previous decades. Those of the next to the last decade are about average.

I have regrouped the data as suggested by Dr. Craighead. Tables II and III are the result. The data are presented in terms of standard deviation of the mean of the entire sample, growth rates between plus and minus 1/3 of the S.D. being considered fair. Growths between minus 1/3 to minus 1 S.D. are poor, below that very poor. Growth rates of plus 1/3 S.D. to plus 1 S.D. are good, over that excellent. This provides for a comparison between decades. The actual ranges of growth for the last two decades, according to the above segregation are as follows:

Decade	1930-38	1920-29
Excellent	Over 36	Over 35
Good	26 - 36	28 - 35
Fair	15 - 25	19 - 27
Poor	4 - 14	11 - 18
Very poor	Under 4	Under 11

Page 3, paragraph 1: In connection with this paragraph I would want to ask to what factors is the sharp reduction in relative growth rate due? If the answer is "general adverse conditions", presumably meaning chiefly adverse physical factors, I feel it describes but a part of the picture. From what our work has shown, it is my belief that flathead borer infestations are but one of possibly many other active factors concerned.

Page 3, paragraph 2: With the exception of Risk I, I believe that the examples are comparable each with the other and are fast growing, but not unusually fast growing trees. The relation of their growth rate to that of the risk class in which each belongs is as follows:

	Percent of growth rate of risk class			
	Risk 1	Risk 2	Risk 3	Risk 4
1930-38	93	184	193	157
Entire period	97	115	110	128

With limitations as to diameter and Keen tree classification which I imposed on myself in order to have comparable trees, there was little possibility of securing individual trees that were exactly representative of each risk class. However, I do not think that the examples are sufficiently inaccurate to give a biased impression.

Page 3, paragraph 3: For tree 774 the figure for average annual growth for decade 1930-1938 should be .026 instead of.062. The figures had been transposed.

Page 3, paragraph 4: According to Glock the basal portions of trees and the northerly exposures ~~are the first to~~ lose rings. Cores were taken from the north side at breast height.

Page 4, paragraph 3: The conclusion attributed to me has not been drawn by me. The paragraphs concerned and the table on page 9 are statements of method and of fact. The underlining of "small basal samples" was intentional to indicate my awareness of the possible deficiencies of that method of sampling.

Page 5, top of page: For Dr. Craighead's information, the mortality percent, in terms of current residual stand, is given in table IV attached.

Page 5, paragraph 2: One has to start a study somewhere. If, as most of us believe, the selection has been going on for centuries and the current ponderosa pine forests of fifty years ago as well as of today are chiefly the products of silviculture practiced by the pine beetle logging company, it would be difficult to find any point from which to start that could not be subjected to the same criticism.

Page 5, paragraph 3: The trees pictures are, of course, but a sample of the entire stand. However, even that sample is enough to convince me that I wouldn't be able to rate risk on the basis either of missing rings or rate of growth.

Page 6, paragraph 1: Although several comments have been made on the changes that have occurred in the risk rating descriptions since 1936, actually little change has occurred in the criteria that are used.

Page 6, paragraph 2: The paragraph might be restated as follows:

51 of the 60 infested trees were high risk trees. Incipient infestations preceded death in 8 of 9 low risk trees and in 43 of the high risk trees. Flathead broods developed successfully in 53 of the trees and preceded subsequent infestations by barkbeetles in those trees.

I have intentionally skipped some of the matter on which there seems to be little agreement. In so doing I may have neglected to furnish or reinterpret evidence that Dr. Craighead may desire. If these omissions are called to my attention I shall be pleased to respond.

Respectfully submitted,

K. A. Salman

K. A. Salman
Entomologist

Berkeley, California
November 12, 1940

Table I. Proportional Standard Deviations of Mean Decadal Growth.

Risks	1		2		3		4		All	
No. Trees	67		45		59		30		201	
Decades	Mean	S.D. in % of Mean	Mean	S.D.in % of Mean	Mean	S.D.in % of Mean	Mean	S.D.in % of Mean	Mean	S.D.in % of Mean
1880-89	40	.42	34	.49	39	.47	42	.53	39	.46
1890-99	45	.38	41	.62	44	.42	51	.41	45	.44
1900-09	48	.38	45	.49	49	.38	55	.45	49	.41
1910-19	41	.41	40	.46	41	.44	51	.48	42	.46
1920-29	24	.53	23	.49	21	.59	26	.44	23	.53
1930-38	28	.72	19	.65	15	.78	14	.79	20	.80

Table II. Segregation of Trees in Each Risk Class by Relative Rates of Growth (by percent of class) Decade 1930-1938

Risk	Excellent	Good	Fair	Poor	Very Poor	Fair or better	Poor or worse
1	22.39	25.37	22.39	28.35	1.49	70.16	29.84
2	11.11	8.89	35.56	44.44	0.00	55.56	44.44
3	5.08	11.86	20.34	53.93	6.78	37.28	60.71
4	6.67	3.33	26.67	53.33	10.00	36.67	63.33

Table III. Segregation of Trees in Each Risk Class by Relative Rates of Growth (by percent of class) Decade 1920-1929

Risk	Excellent	Good	Fair	Poor	Very poor	Fair or better	Poor or worse
1	22.39	10.45	29.85	22.39	14.92	62.69	37.31
2	13.33	17.78	24.44	33.33	11.11	55.55	44.44
3	10.17	8.47	37.29	27.12	16.95	55.93	44.07
4	16.67	20.00	33.33	26.67	3.33	70.00	30.00

Table IV. Percent of Stand Killed by Insects

Year	Percent Currently Residual Stand		
	Number Trees	Volume	
1920	0.5	0.4	
1921	0.2	0.1	
1922	0.5	0.4	
1923	1.7	1.1	
1924	5.8	5.5	
1925	5.1	5.4	
1926	10.2	10.2	
1927	13.4	13.9	
1928	3.3	2.9	
1929	2.4	2.2	
1930	4.1	3.2	
1931	10.6	10.7	
1932	22.1	20.6	
1933	14.8	14.4	
1934	10.9	12.1	
1935	23.3	21.6	
1936	4.7	4.1	
1937	12.7	11.4	
1938	4.2	2.7	
1939	6.1	4.6	
1940	2.2	3.9	Incomplete

DATA ON 16 TREES USED AS ILLUSTRATIONS IN REPORT ON
GROWTH, RISK AND INCIPIENT INFESTATIONS - TIMBER MOUNTAIN

DECADE		1930-1938		1920 - 1929		1910 - 1919		1900 - 1909		1890 - 1899		1880 - 1889	
RISK 1936	TREE NO.	DECADE TOTAL	AVE. ANN.	DECADE TOTAL	AVE. ANN.	DECADE TOTAL	AVE. ANN.	DECADE TOTAL	AVE. ANN.	DECADE TOTAL	AVE. ANN.	DECADE TOTAL	AVE. ANN.
1	1034	139	15	191	19	463	46	461	46	442	44	386	39
	1207	259	29	320	32	557	56	808	81	546	55	314	31
	1209	100	100	100	10	322	32	484	48	396	40	292	29
	1169	132	15	197	20	346	35	380	38	366	37	353	35
	1307	100	11	375	38	476	48	601	60	577	58	508	51
	1312	217	24	436	44	516	52	720	72	927	93	306	31
TOT.		947		1619		2680		3454		3254		2159	
AVE.			18		27		45		58		54		36
2	870	116	13	241	24	488	49	713	71	678	68	657	66
	1474	151	17	279	28	561	56	569	57	452	45	299	30
TOT.		267		520		1049		1282		1130		956	
AVE.			15		26		53		64		57		48
3	1168	41	5	88	9	184	18	293	29	381	38	476	48
	1208	105	12	221	22	569	57	946	95	770	77	427	43
	1306	161	18	417	42	638	64	832	83	649	65	661	66
	1311	72	8	202	20	432	43	557	56	555	56	709	71
TOT.		379		928		1823		2628		2355		2273	
AVE.			11		23		46		66		59		57
4	1170	64	7	138	14	223	23	311	31	295	30	209	21
	1310	24	3	155	16	409	41	342	34	339	34	343	34
	1457	37	4	248	25	400	40	577	58	535	54	622	62
	1475	151	17	294	29	692	69	850	85	655	66	401	40
TOT.		276		835		1724		2080		1824		1575	
AVE.			8		21		43		52		46		39

MEMORANDUM FOR MR. J. M. MILLER

Attention is called to Dr. Craighead's criticisms of October 15, 1940 and my reply of November 12, 1940 with reference to statements contained in my report of August 21, 1940 entitled "A preliminary study of the diameter growth of ponderosa pine and some of its relations with risk and incipient infestations of the flathead borer (Melanophila californica VD.) In a recent conversation Dr. Hall brought out that perhaps Dr. Craighead considered that the 16 tree s used to compare growth patterns and lack of complements with the characters used in classifying risk were a sample of the stand and had concluded that their growth record was different from that given for the stand as a whole.

In explanation, it may be restated that these trees were considered as examples and not as a sample of the stand as a whole. The trees used were those which had been taken in group pictures originally photographed to show conditions on the Timber Mountain plot. The fact that a comparison could be made between tree characters and cores and that illustrations were at hand was an afterthought in the study and, as stated before was a by product, not the main theme.

Unless care were used in selection, it would be highly improbable that a 16 tree sample, taken at random would give the same growth picture as the average of the 201 tree stand sample. The variation in relations between growth and risk is too great.

Because of the criticismand thepossibility that Hall's suggestion applied a study was made of the growth record of the 16 trees. During the past decade the growth relations were those of the entire sample. That has already been considered by most to be the most significant period of growth relation to risk. Past growth records of other decades are, however, not those of the entire sample. I believe that is explained easily. The four trees in risk 4 are below the normal growth for their risk group. The twelve trees in risks 1, 2 and 3 all average above the normal for their risk groups. Thus the differences between risks, already great are accentuated by these examples.

It would appear to me that this lack of relationship between growth and risk only accentuates statements made that it does not appear that the growth record is one which has a critical relation to risk ratings. The variations are too great. Further force is given that attitude by the fact that, of the 16 trees, 9 of them changed during the 59 year period from growths above the average for their group to below, or vice versa. Thus even the same trees do not always have growth rates similarly relative to the group to which they belong.

I believe the consideration of growth rates and risk as being closely associated, the one indicative of the other , can easily be overdone. Constant relations do not seem to exist and this 16 tree sample also bears out that conclusion.

Respectfully submitted.

February 8, 1941 K.A.Salman